SEAFRAME

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FROM THE TOP

BUILDING AN AFFORDABLE FUTURE FLEET

By Captain Chris Meyer, Pat Woody and Captain Alexander S. Desroches

When Vice Adm. Kevin McCoy took the helm of NAVSEA his first act was to initiate a 100-day Agenda for Change. I'm proud to say that thanks to your efforts and those of the other members of the NAVSEA Team, he has been able to move a number of his initial action items into a "done pile." In its last issue, SEAFRAME was devoted to our support of the vice admiral's goal of Sustaining Today's Fleet Efficiently and Effectively. The current issue will be dedicated to some of Carderock Division's efforts on behalf of another goal: Building an Affordable Future Fleet. We all know there is no quick panacea to achieve this end. For some time, however, we have worked on efficiencies that will help us reduce our business cost. These efforts are beginning to show results and have helped prepare us for our current challenge of reducing our programmatic and technical costs.

The expertise of everyone is required to develop solutions–from our civilian and military leaders to the Sailor who has to work with the outcome. Recently, U.S. Secretary of Defense Robert Gates unveiled his department's proposed 2010 defense budget. His budget included a series of decisions that focus on shipbuilding in the years ahead. One of his proposals is to move from creating new and long-term ship designs to those that are proven and affordable. As Capt. Mark Thomas (former commander, Carderock Division) has pointed out on numerous occasions since then, "if we reduce the number of types of hulls in the future fleet the commonality efforts that McCoy championed as SEA 05, and still champions today, will have a much bigger payoff."

This means that open architecture of components, systems, and hull forms will become even more important in the future. Influencing component selection by getting involved in the acquisition process earlier is a primary objective at our Philadelphia site. For example, the commanding officer, Capt. Alexander Desroches, likes to point to a relatively straightforward acquisition decision such as the littoral combat ship diesel cooler. With the exception of the outside casing, it is basically the same as the diesel cooler on the mine countermeasures. If we had been working with the customer earlier in the acquisition phase, we could have pointed out the advantages of keeping the outside cooler casings the same to gain some cost savings and efficiencies.

As noted by McCoy, seventy-five percent of the future fleet is in operation today. These ships have to operate and maintain warfighting capability until the end of their planned 35-year service life. Therefore, modernization is another important focus when planning for an affordable future fleet. As an example, our people at the Philadelphia site recently upgraded and installed a Power Management Platform that works with the Machinery Control System in the *USS Blue Ridge*. It significantly increased the reliability of an electrical system that was plagued by outage failures. The systems have also been installed on the *USS Gunston Hall*.

In response to the vice admiral's call to do only what is absolutely necessary, we have worked with our supervisors to promulgate a work definition policy. It is designed to standardize and support efforts that help customers make smart buying decisions. This policy has two main objectives. The first is to become more engaged with the customer during the informal phase of the tasking process. Many decisions are made during these early stages before formal negotiations begin, and they may be difficult or impossible to reverse.

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The SEAFRAME staff reserves the right to edit or rewrite all submissions.

The front cover suggests the various efforts the Navy is involved with to make our fleet mission-capable while addressing lowering the costs associated with creating and maintaining that fleet. The "313" symbolizes our commitment to a 313-ship Navy, keeping our capabilities high and our acquisition and sustainment costs low. This issue of SEAFRAME is devoted to highlighting the efforts of Carderock Division's superlative workforce of men and women to meet head-on the challenges of building an affordable fleet now and into the future.

U.S. Navy photos.
Cover design by Gloria Patterson, NSWC Carderock Division.

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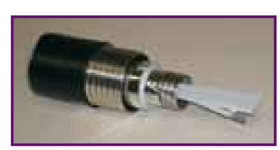

FROM THE TOP

BUILDING AND AFFORDABLE FUTURE FLEET (Continued on page 2)

The second is to facilitate efficient and cost effective solutions by providing program decision-makers with more technical options and advising them on any associated technical risks.

Carderock Division supports the Navy by providing technical capability in naval architecture and marine engineering for both the current and future fleet. To enhance the Navy's future war fighting capabilities we have been working on cost-effective solutions that will help ships meet the increased power requirements of their mission loads. Adapting commercial developments such as using insulated bus pipe (IBP) for shipboard transmission lines could save the Navy time, money, weight, and space. In addition, IBP holds the potential for new Navy electrical distribution system designs that can reduce vulnerability, enhance survivability, and reduce ship fabrication costs.

We are also looking at innovative testing methods and analysis that can achieve significant cost savings for the Navy. For example, acoustic target strength signature control technologies and analysis methodologies have evolved to the development of a prediction tool and a real-world measurement scenario that was used to certify key performance parameters for a submarine class operational requirements document. The development and use of this too–Target Strength Predictive Model and the accompanying real-world verification technique resulted in significant cost savings to an acquisition submarine program office and should lead to significant cost avoidance for future Navy programs.

Two other examples of our affordability efforts can be found in our composite materials research to increase the payload and range of future Navy ships and our investigation into methods to mitigate downtime and asset degradation due to corrosion. We are also trying to find answers to some of the environmental challenges that create work and increase costs.

You will read a lot more in this issue of SEAFRAME about our efforts to support Vice Adm. McCoy's direction of Building an Affordable Future Fleet. Obviously, we cannot cover all of our endeavors in this one magazine, but affordability is and will continue to be a Carderock Division thrust. We are making significant progress, and we will continue to move forward.

Above: The amphibious command ship *USS Blue Ridge* (LCC 19) is underway in the Pacific Ocean. *U.S. Navy photo.*

BUSINESS

PILOT PROGRAM INITIATIVES

Supporting the Strategic Business Plan by Offering Customers Cost Reduction Options

By Vincent Wagner

In July 2008, Vice Adm. Kevin McCoy called upon the Warfare Centers to support Naval Sea Systems Command (NAVSEA) Strategic Business Plan goal of lowering costs by identifying cost reduction options for customer approval. The intent was to develop an overall methodology that would be applicable to most future task statements. The vice admiral established two pilot programs relating to our existing task statements, one of which is the Hull, Mechanical and Electrical (HM&E) Pilot, under the direction of Marc Magdinec, Warfare Center Surface Senior Executive.

NAVSEA's concern with the current task statements was that the broad language used by Program Executive Officer and Program Managers, Directorates, and the Warfare Centers might not be immediately transparent in defining the tasks required to achieve the overall program goal. They also expressed the desire for more clarity between the technical point of contact and the customer on specific deliverables. While they recognized the current approach provides both the program manager and Warfare Centers needed flexibility during task execution, they believed that the process could create inefficiencies and encouraged an unnecessary level of effort. Furthermore, they were concerned that under the current system customers had limited ability to assess the risk and impact of not performing or delaying the execution of work.

The initial objective of the pilot program was to get immediate financial savings that would generate funds for other navy priorities. Subsequent to the introduction of the pilot, NAVSEA determined that redirection of these funds was not a viable option without Congressional level approval. It was decided that in most cases, the savings identified would be turned over to the sponsor for reissue to higher priority tasking. Although the ultimate direction of the money was changed, it did not alter the initial concept or the pilot or our approach.

Magdinec, with agreement from the appropriate sponsor leadership, narrowed our HM&E Pilot down to specific areas, focusing on the DDG 1000 Program and In-service Ships. To help organize information, we received support from Program Customer Advocates Bill Merryman, Joe Amadoro, and Dave Rich. D.J. Benedetti, the Lead Customer Advocate for Surface, was also involved in the pilot, responsible for coordinating the SEA 05 efforts that didn't fall under Joe or Dave, and helping to coordinate the overall package. We also received a lot of help from the Directorates within the Carderock Division.

As the first step of the pilot, Magdinec formed a team consisting of personnel from SEA 05, SEA 21, and PEO SHIPS, along with Warfare Center personnel from Carderock, Dahlgren, and Panama City Divisions. Together, we reviewed the Task Planning Sheet (TPS), the formal document used by the sponsors to document tasking. This review covered the statement of work, funding levels for both the current and out years, deliverables, key personnel, signatories, and other information relevant to the customer. We first examined the documents for clarity and, where necessary, edited them to assure some standardization. We also reviewed the facts pertaining to funding, delivery, monetary amounts, deliverables, milestones and the POA&M to determine if they were accurate and met program requirements. For the most part, all information was satisfactory or simply required minor adjustments. The TPSs are a top level document that roles up information from various meetings, discussions and other documents, into a single source for all information. When we reviewed these documents, we all realized that to someone not intimately familiar with the specific tasks, the documents could be confusing if all sections were not filled in, so we made an effort to make sure the TPSs were complete.

This effort certainly made the documents more standardized and clear to those not regularly involved in the tasking, but it did not prove to be a tool for significant cost savings. One significant benefit was it allowed the three sponsors to review each others TPSs, and they gained an appreciation for tasking ongoing in the other areas that effect their tasking.

PILOT PROGRAM INITIATIVES (Continued on page 6)

Supporting the Strategic Business Plan by Offering Customers Cost Reduction Options

PILOT PROGRAM INITIATIVES (Continued from page 5)

Our next step was more productive in generating some savings. In this phase of the HM&E Pilot we developed an impact statement for every task based on 5, 10, and 15 percent funding reductions. These impact statements could be alternative ways to accomplish tasks and/or increasing risk on a task by decreasing some minor subtasking. This effort was really no different from the approach we took when originally developing the tasks, the benefit gained here was for some tasking, new information was now available that helped us better understand the problem statement and find different solutions for addressing the issues. We also were able to discuss with the sponsors the current return on investments for tasking to see if it might make sense to eliminate the tasking because of a projected low return. In other cases, we were far enough along in the work to realize some tasks were no longer necessary, or could be reduced in scope. These evaluations were not entirely new to us they are part of our day-to-day communication with our customers. However, under the HM&E Pilot we used a more structured approach with the objective of providing the Program Manager with more information to make an informed decision about the cost/risk benefits of each undertaking.

Of course, any decision is not easy. These documents are developed in the spring and through the summer time frame and as events unfold, certain predictions have to be changed. For example, we may think we are going to do an installation on a certain ship at a certain time, only to have the ship's schedule change, rendering the ship unavailable. Alternatively, the ship may be available, but our testing may reveal something unanticipated requiring a change to the original plans. In other words, the work we do cannot simply be approached like an assembly line. A host of things can happen that will undo our most carefully thought out tasking statement. Thus, in making their decisions, the customer must look at probabilities that cannot even be imagined at the time of tasking. One way we currently mitigate some of the unexpected contingencies is through frequent meetings between the program manager and technical personnel. In these meetings we not only reassess the status of ongoing work, we also discuss the internal reallocation of resources from a task that is performing better than expected to one that is not.

After completing our HM&E Pilot risk assessment, we presented our findings to the sponsors. $11.8M in savings was identified across all sponsors from all Warfare Centers, $5.6M of which was savings related to Carderock Division tasking. Most of the savings arose by increasing risk. Some of it occurred because we were further along in the work and had more ideas about what we could do to reduce costs. And, in a few cases, we found a way to reduce the costs by doing things differently or clarifying specific tasking.

One of the more important results is that we were able to show NAVSEA leadership, the sponsors, and ourselves that the Task Planning Sheets are fairly informative documents when they are filled out completely. We were also able to show that Carderock Division's working relationship with the sponsors is very good. The sponsors agreed that future information sharing between sponsors is something they are interested in because it will improve their knowledge of what is being done on other tasks and provide them with additional information to improve their programs and mitigate risks.

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CUSTOMER ADVOCACY

The Littoral Mine Warfare Program Executive Office

Carderock Division CAs Help PEO LMW "Build an Affordable Future Fleet"

By Ron Warwick, Dave Cleland, and William Palmer

As part of the change in Warfare Center (WC) management, customer advocates (CAs) were realigned to serve as principal agents of the five WC National Workload Managers (NWMs). These advocates provide overall project management and oversight for all projects under their cognizance at their divisions. They are responsible for maintaining a national perspective, advocating for their assigned customers, and under the direction of the NWM, assuring work is assigned to the appropriate WC sites.

The customer advocates are also responsible for managing the WC division relationships with sponsors, program offices, and foreign national contacts, especially in the case of foreign military sales. They negotiate cost proposals and tasking for all program work performed at their division and collaborate with other WC division sites on program-specific initiatives and proposals. In support of the commander and technical director of the Naval Surface Warfare Center (NSWC), Carderock Division, these advocates work closely with technical project managers and engage in meaningful cost, schedule, and performance discussions with the customers.

In the case of Unmanned Vehicle (UVs) acquisition engineering support within the Division, Dave Cleland is assigned as the CA for the Program Executive Office Littoral Mine Warfare (PEO LMW). In this position, he speaks on behalf of the Division regarding workload commitments, cost, schedule, and performance status. In cases where multiple WCs are needed to support a program, the CAs from each WC collaborate to develop one integrated WC proposal. In the area of UVs, PEO LMW provides numerous opportunities for Carderock Division to leverage its technical capabilities to support our focus area of "Building an Affordable Future Fleet."

PMS 403 is the Unmanned Maritime Systems Program Office under PEO LMW. Two of the UV projects under PMS 403 that Carderock Division supports are the Mine Countermeasures (MCM) Unmanned Surface Vehicle (USV) and Anti-Submarine Warfare (ASW) USV.

The MCM USV task for Carderock involved the design, development, integration, test, and delivery of the USV platform with integrated Command and Control (C2). Carderock also supported the integration and test of the MCM Payload system along with the associated

WARFARE PROGRAM EXECUTIVE OFFICE (Continued on page 8)

Right: An MCM USV.
Photo courtesy of NSWC Panama City and PMS 403.

WARFARE PROGRAM EXECUTIVE OFFICE (Continued from page 7)

ship-to-USV communications system. The payload is a MCM sweep system which includes primary components such as a power generation unit, winch, payload control system, and the towed magnetic/acoustic sweep. There are currently two Engineering Development Models (EDMs) delivered, undergoing testing and integration with the Littoral Combat Ship.

The working MCM USV team consists of NSWC Carderock Division as the USV Craft Technical and Interface/Integration lead, NSWC Panama City Division as the Mission Package System Integration and MCM payload lead, and SPAWAR Charleston, as the C2 lead. Carderock Division provides technical expertise for the USV primarily from Carderock's Combatant Craft and the Marine and Aviation Divisions. This has been an extremely successful team arrangement that leverages and highlights the core technical capabilities and knowledge areas of each WC. The CAs from Carderock and Panama City Divisions have worked closely together with PMS 403 to coordinate the tasking and funding between the WCs to meet cost, schedule, and performance agreements. The recent successful completion of the fully unmanned MCM mission profile scenario testing at Panama City Division highlights the strong integrated project team support and technical expertise of the WC collaborative approach for this program.

The ASW USV Carderock program tasking has involved evaluating the existing ASW Craft and providing safety review and program oversight for the NAVSEA Technical Authority Warrant Holder for combatant craft and boats. Combatant Craft Division personnel conducted rough water testing, physical craft audits, documentation reviews, and supported the numerous ASW USV test events. Under the current construct, Naval Undersea Warfare Center, Newport Division is the team lead for the ASW USV program with collaborative site support from Carderock Division and several other WC divisions.

The ASW USV system currently consists of two Engineering Development Model (EDM) USVs craft capable of carrying mission-dependent ASW payloads. Operational scenarios may involve both EDM USVs with complementary payloads operating simultaneously in a coordinated approach or as a single EDM USV and payload coordinated with another mission platform and associated sensor.

The WC CAs worked with the site Technical Project Managers (TPMs) and PMS 403 Program Manager (PM) to provide a consolidated project tasking plan, budget, and schedule. Iterative CA working meetings during the budgeting process with Carderock Division and NUWC TPMs facilitated an executable approach within the PM's fiscal constraints. The CAs from both WCs also enabled resolution of project concerns and issues by facilitating sponsor and project lead communications and by providing potential solutions.

Above: MCM USV conducting sweep operations.
Photo courtesy of NSWC Panama City and PMS 403.

Above: MCM USV in transit.
Photo courtesy of NSWC Panama City and PMS 403.

In both of these USV projects the CAs from three WC sites have worked closely together to enable the successful execution of these projects to meet PM expectations and goals. The working relationships and teaming arrangements have served as a framework and example for future collaborations and mutual successes between the WCs. The CAs continue to guide and nurture the WC team collaboration, cooperation, and ultimate financial and performance based success of these programs in support of our customers.

Above: An ASW USV.
Photo courtesy of NSWC Panama City and PMS 403.

Above: An ASW USV configured with dipping sonar.
Photo courtesy of NUWC Newport and PMS 403.

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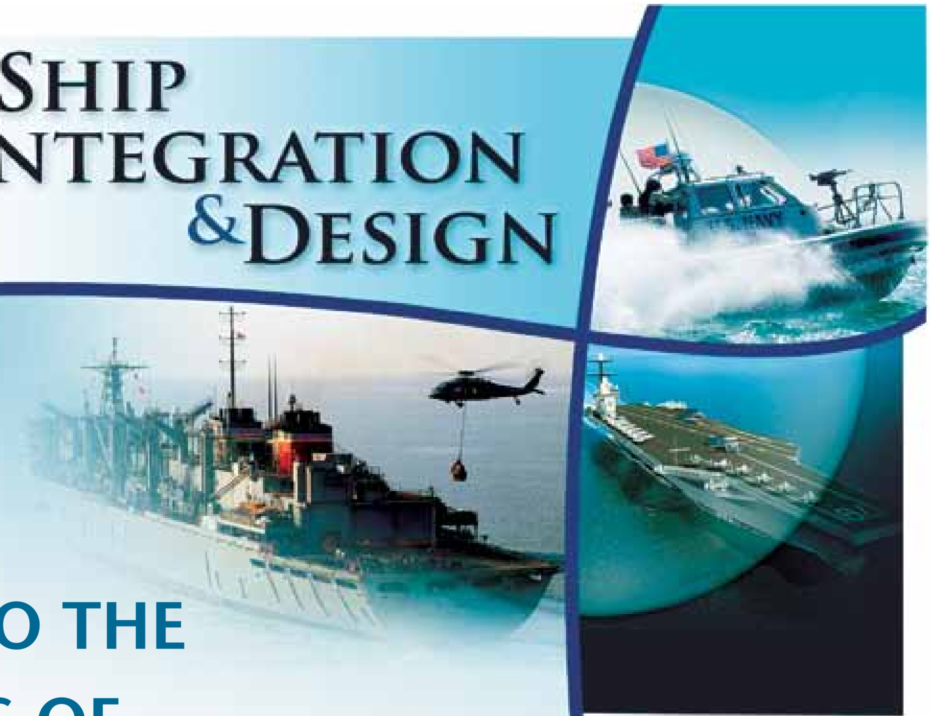
SHIP INTEGRATION & DESIGN



RESPONDING TO THE CHALLENGES OF RE-SUPPLY AT SEA

Operational Logistics Successes at Carderock Division

By Charles Traugh

"It's a mess out there." Logistics is a messy business. Parts, food, and ammo come in an infinite variety of sizes, shapes, and weights with special storage and handling needs. In today's global environment, all shipments are mission critical ... you need what you need, when you need it, where you need it, regardless.

The U.S. Navy must provide a persistent global presence, frequently without ready access to ports for re-supply. This makes movement of material at sea an absolute necessity. Today's operating environment requires a higher tempo of operations at sea with smaller crews. Speed and accuracy of delivery must also be improved.

The entire logistics system-of-systems must work together to provide effective logistics delivery. In 1999, the Navy conducted a study of existing capabilities and highlighted several areas for improvement along with broad approaches for getting there. Navy technical involvement and support in response to these emerging naval concepts has been through the Operational Logistics Integration Program (OPLOG). OPLOG is an OPNAV N42 (Strategic Mobility and Combat Logistics) program, administered through PMS 385 (Strategic and Theater Sealift Program Office), and managed through the Naval Surface Warfare Center, Carderock Division's Code 2120.

Working with OPNAV requirement sponsors, the Naval Surface Warfare Center, Carderock Division has been involved in formulating, coordinating, funding, and managing many of the overall RDT&E efforts that will form the basis for the logistics capabilities of the "*Next Navy*" and the "*Navy After Next*."

The OPLOG program is organized around several "themes" collectively comprising afloat operational logistics:

<u>Advanced Replenishment System</u> is a significant enabler of persistent support of Naval forces at sea for Sea Strike, Sea Shield and Seabasing. OPLOG is developing, testing and fielding a Heavy Underway Replenishment (UNREP) System that will dramatically improve the capabilities of legacy UNREP equipment in use today. Heavy UNREP development includes advanced electric winches to provide more precise control and significantly reduced maintenance manpower, time and cost. A wireless ship-to-ship voice and data transfer system is also being evaluated to replace current phone and distance lines and station-to-station sound powered phone connections.

<u>Integrated Material Movement</u> seeks to improve the movement and storage of material within the ship. A prototype Automated Storage and Retrieval System (ASRS) is being developed and demonstrated that enables selective offload and dramatically improves Strike-Up/Strike-Down

(SUSD) of supplies. Selective offload refers to the ability to tailor the flow of supplies to forces ashore by having the flexibility to pull, stage and offload supplies from fleet supply ships in any order or volume without increasing the customer wait time. SUSD refers to two distinct portions of the at-sea cargo transfer process. Strike-Up refers to readying cargo and moving it from its storage location to the offload point onboard the distribution ship. Strike-Down refers to the transfer of the cargo and its storage onboard the receiving ship or by forces ashore.

Asset Visibility and Planning is an effort to enable Total Asset Visibility (TAV) within the afloat operational logistics supply chain by integrating the development of enabling technologies. OPLOG has supported development and evaluation of a number of automated identification technology (AIT) options, including 2-D barcodes and radio frequency identification (RFID) tags for shipboard applications.

Standardized Containerization recognizes that "It's a mess out there." Improving cargo-handling efficiency requires a reduction in the multitude of sizes, shapes, and weights of current cargo packages. OPLOG is targeting a significant reduction in cargo package variation through the development of a standardized Joint Modular Intermodal Container (JMIC). The current JMIC development effort addresses the need, technical characteristics, and military utility of a baseline family of JMICs, all with a common dimensional footprint and interface. A JMIC Interface MIL-STD is being developed to assure consistency of hardware amongst multiple manufacturers while reaping the cost benefits of competition in any large-scale procurement.

The JMIC has been purposefully developed to integrate seamlessly with standard twenty-foot equivalent unit (TEU) loads, or other commonly used platforms, into warehouse pallet-sized loads that are AIT-enabled. JMICs can be transported as single or multiple units. Sixteen JMICs will fit into a TEU with minimal blocking and bracing.

Several JMIC variants are being developed including a 3,000-pound capacity and a lightweight 1,500-pound capacity. The JMIC Standard includes vertical stacking and locking that allows the sides to be

RESPONDING TO THE CHALLENGES OF RE-SUPPLY AT SEA (Continued on page 12)

Top and side: These photos show some of the current logistics re-supply practices which RDT&E efforts seek to change or update.
Photos provided by Jeff Benson, NSWC Carderock Division.

"It's a mess out there . . . Thousands of items to keep track of in a wide variety of sizes, shapes, and weights."

Photo provided by Jeff Benson, NSWC Carderock Division.

RESPONDING TO THE CHALLENGES OF RE-SUPPLY AT SEA (Continued from page 11)

opened even when stacked. JMICs are top-liftable and have four-way fork pocket entry to facilitate movement through the supply chain. Standardized dimensions also facilitate materiel-handling automation such as the ASRS to reduce required manning. JMICs are collapsible for retrograde, so three collapsed JMICs travel in less volume than one assembled JMIC.

If approved and accepted, JMIC's transition will follow an incremental development process supporting an evolutionary acquisition approach. This will provide for the time-phased introduction of JMICs in a manner that concurrently evaluates and mitigates significant risk, affordability, and military-utility issues.

Energy Conservation development efforts were recently kicked-off to pursue innovative applications for Navy shipboard energy conservation and carbon footprint reduction with the potential for rapid transition to fleet operation. The target segment of the fleet is the ships operated by Military Sealift Command: Combat Logistics Force, Auxiliaries and Sealift.

A number of significant energy saving initiatives are already underway, including conduct of energy audits to provide an accurate picture of the total energy used by various systems in various operating conditions; installation of accurate fuel meters; application of specialized hull coatings; and evaluation of a performance based navigation system to enable more efficient ship routing.

The OPLOG "themes," while specific in focus, are part of a larger, integrated approach to improving afloat operational logistics and influencing seabasing.

Working within a collaborative Naval, DOD, and commercial development environment, OPLOG seeks to mature, integrate, and transition appropriate operational logistics technologies. ONR, Systems Commands, and PEOs comprise the Navy's science and technology expertise, and acquisition and fielding arms. Additionally, in the post-S&T, pre-acquisition arena, OPLOG is working together with these communities as well as OPNAV, the fleet, Academia and Industry to support and transition an integrated suite of logistics technologies.

Top: The Military Sealift Command fast combat support ship *USNS Rainer* (T-AOE 7) performs a replenishment at sea with the nuclear-powered aircraft carrier *USS Nimitz* (CVN 68) on April 12, 2007. The *Nimitz* Carrier Strike Group is deployed in the Pacific Ocean in support of operations in the U.S. Central Command area of responsibility.
U.S. Navy Photo.

Above left and right: The JMIC is one containerized solution being considered for reduction of cargo package size variation.
Photos provided by Jeff Benson, NSWC Carderock Division.

OPLOG is also engaged in cross-DOD logistics development efforts to ensure joint capabilities are fielded. One example, the Joint Modular Intermodal Delivery System Joint Capability Technology Demonstration (JCTD) project is demonstrating standardized containerization equipment compatible with commercial intermodal and military-unique transportation networks. The Navy and Marine Corps contribution to this project is the JMIC. This JCTD includes participants and resources from the Navy, Marine Corps, Army, U.S. Transportation Command, Defense Logistics Agency, and Air Force.

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HULL FORMS & PROPULSORS

ENVIRONMENTAL MONITORING AND OPERATOR GUIDANCE SYSTEM AND CHANNEL ANALYSIS AND DEPTH EVALUATION TOOL

A Set of Tools Which Save Dredging Costs and Help Deep-Draft Ship Navigation

By Charles Traugh

In the 1980s, the Navy became aware of grounding problems with deep-draft ships entering ports through channels exposed to waves, specifically at Kings Bay, Ga. The recommended channel depth for unrestricted access to the Naval Submarine Base at Kings Bay was a 55-foot depth. Dredging costs had escalated to the point where the Navy could afford to maintain only a 46-foot depth in channels. Dredging to this depth, ships had a probability of grounding 10 percent of the time, and the Navy wanted to establish a method to determine when the transiting through that channel was safe.

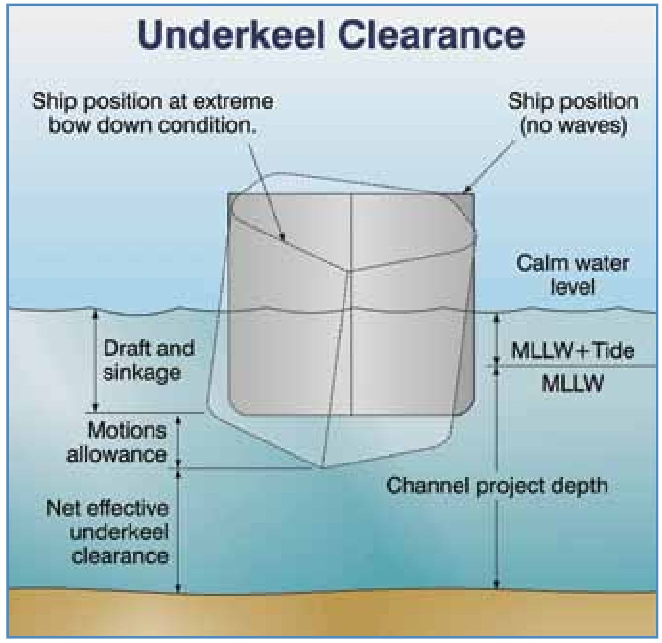
To solve this problem, Carderock Division engineer Andrew Silver came up with the Environmental Monitoring and Operator Guidance System (EMOGS), a computational method used by the submarine squadron to determine whether the environmental conditions in the channel will provide enough under-keel clearance to permit transit of a channel minimizing the possibility of grounding. It saves the Navy money by permitting use of a channel whose depth is less than required for unrestricted access by actually calculating distances between a ship's keel and the channel bottom. The shallower entrance channel depth precludes expensive and unnecessary dredging operations. A test of the system came shortly after EMOGS was installed in the wake of Hurricane Hugo in 1989. EMOGS predicted a large risk of grounding due to the large vertical submarine motions produced from the hurricane waves. From this EMOGS prediction, the submarine was waived off from transiting the channel during that time.

EMOGS calculates the risk of grounding by calculating the difference between the depth of water in the channel and the predicted extreme vertical displacement of the deep draft ship. Astronomical data are used to calculate tidal heights, and measurements of weather-related phenomena, such as the presence of high pressure or low pressure atmospheric pressure patterns, are gathered. Wind speeds and directions that could increase or decrease the water level in the channel are also taken into account. Finally, U.S. Army Corps of Engineers surveys are examined for potential areas of rapid sediment build-up, or "hotspots." The factors included in calculating extreme vertical displacement of the deep-draft ship are the ship's static draft, its sinkage and trim at speed, and the wave-induced vertical motions at each end of the ship. The wave-induced vertical motions are calculated by combining the heave and pitch response amplitude operators with the measured wave spectra from buoys located along the channel.

Left: The long wave periods shown in this photo indicate the importance of wave action in figuring the required underkeel clearance for a ship, especially an aircraft carrier, to navigate a harbor channel without grounding.
Photo provided by Andrew Silver, NSWC Carderock Division.

Below: A diagram showing some of the factors taken into account when determining the clearance between a ship's keel and the bottom of the channel. The EMOGS/CADET programs save the Navy millions of dollars in dredging costs per year.
Graphic provided by Andrew Silver and rerendered by Gary Garvin, both NSWC Carderock Division.

Above: The *USS Ronald Reagan* (CVN 76) navigates through heavy seas in the Pacific Ocean. An aircraft carrier can exhibit as much as 27 feet of vertical pitching movement from such wave action.
U.S. Navy photo.



Because the waves measured by the buoy are not the same waves that the deep-draft ship would actually experience, a statistical formula is applied to the predicted motion to yield an expected extreme vertical displacement. In that way, a worst case scenario would be used in calculating the predicted underkeel clearance. The process was validated by comparing data from the inertial navigation system of one of the submarines as it passed the buoys by the channel with the predicted motions from EMOGS using the measured waves in the channel.

USS Pennsylvania (SSBN 735) was the first ship to transit the 11-mile long entry channel to the Kings Bay port, using EMOGS as an advisory source of information in 1989. The submarines have used EMOGS guidance for every channel transit since that time. In 1995, EMOGS was also installed at Port Canaveral to provide underkeel clearance guidance for SSBN transits of that channel as well.

EMOGS met with great success at Kings Bay, and the technology was used to counter another potential grounding situation which aircraft carriers might face while moving through channels in the San Diego approach area. Because an aircraft carrier can have as much as a 27-foot vertical movement due to its environment, a range of channel depths were studied for San Diego. This study determined a channel depth that provided the most number of days per year of safe transits by using the probability of occurrence of different wave conditions from a 20-year wave climatology off the San Diego channel. Using the traditional deterministic methods, the safest dredge depth the Navy would have had to dredge the channel was 60 feet, whereas the new probabilistic method calculated a safe depth of 55 feet. The 5-foot difference in required dredge depth saved the Navy $16 million in dredging and precluded the possibility of dredging up additional hazardous materials from the channel bottom.

From the procedure used at San Diego, an application known as Channel Analysis and Depth Evaluation Tool (CADET) was born. CADET is used to predict the

ENVIRONMENTAL MONITORING (Continued on page 16)

Left: An aerial view of the channel approach to Kings Bay. The channel is in the center and right center, and is about 11 miles in length. EMOGS uses wave measuring buoys and measured tide levels to assist harbor personnel in figuring whether the channel can permit the safe passage of ships.
Photo provided by Andrew Silver, NSWC Carderock Division.

Above: The *USS Pennsylvania* (SSBN 735), pictured here, was the first ship to transit the channel approach to Kings Bay using the EMOGS system to determine whether the channel could accommodate the ship's draft.
U.S. Navy photo.

Left: The *USS George Washington* (CVN 73) moves past buildings in the downtown area of Norfolk, Va. CADET is a successful optimized channel depth prediction tool which helps such ships safely navigate port channels and is used in both domestic and global ports.
U.S. Navy photo.

ENVIRONMENTAL MONITORING (Continued from page 15)

optimum channel depth that minimizes the amount of required dredging and affords the maximum number of days per year of accessibility or safe transits. The application is written in FORTRAN, with a graphical user interface written in the C++ language. It first calculates wave-induced motion based on the wave climatology at a specific location, calculates the risk of grounding for a range of dredge depths then determines the accessibility of the channel based on the number of days per year each wave condition occurs at the port. CADET has been so successful in its channel design abilities that it has been used to determine the required depths for the entrance channels to Yokosuka, Japan; Bahrain; Rota, Spain; and in the United States at Pensacola and Mayport, Fla. and Norfolk, Va.

In the early 2000s, Carderock engineers, responding to a Corps of Engineers request for enhancements to the CADET tool, added a library of different commercial ship designs, including hull characteristics, ship geometries and associated response amplitude operators, to expand the application's flexibility in using data from multiple ship designs. CADET is now in the process of being adopted as the Corps of Engineers design tool determining the optimum depth for all the channels in the United States.

Carderock Division has been instrumental in developing EMOGS and CADET to provide operational and design capabilities relative to entrance channel dredge depths which, in turn, saves precious budget funds for redirection to more immediate mission needs.

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MACHINERY SYSTEMS

RELIABILITY MODELING

Combining Several Prediction Models to Sharpen Design Acumen

By William Palmer

Some teams of the Naval Surface Warfare Center, Carderock Division, spend almost all of their time increasing the efficiency of a process. In the Division's Advanced Machinery Systems Integration branch in Philadelphia, 85 to 90 percent of the branch personnel work to steadily improve and enhance system design decisions. One part of these decisions involves component and system reliability. When the group engages in advanced machinery design, modeling the reliability factor of those designs helps save time and money, and affects the acquisition and shipbuilding processes.

Reliability modeling is intimately tied to other modeling and simulation processes, computer programs and environments to extract the most effective system design possible from available configurations. Tools such as an energy calculator, cross-performance modeling, ship efficiency and thermal modeling can be brought into play to develop the entire set of feasible system designs. Different design alternatives can be explored by subjecting the ship design to scrutiny by the various efficiency tools. Not only can design features be analyzed, but they can also be changed from within the domain of the modeling tools to determine the best design that meets all of the key design parameters. In the long term, the most important questions to answer are those concerning ship life cycle cost, reliability and performance.

When you ask how much money can be saved using reliability modeling, you're going to get a myriad of responses, and it varies study by study. Factors such as fuel cost can even vary with time when using an energy calculator because as fuel costs fluctuate, efficiency and money saved by using a particular ship design or propulsion system can vary. Many times, deriving the cheapest design solution is not the most desirable design goal. "You may have lots of factors people want to trade off," says Tim Klingensmith, head of the Philadelphia branch. "They might want something that gives them the greatest range of operation for a given amount of money, coupled with the best reliability possible in that mix of range and cost. It's a multi-parameter decision you're trying to make, so it can be difficult to pinpoint."

A reliability model can take anywhere from a few seconds to a few days to execute. The length of time depends on the complexity of the model. For instance, if an entire ship design is being modeled, the process could execute, but varying parameters with each execution, as many as one thousand iterations are processed, each iteration taking about 20 minutes to complete.

Currently, the group is performing a total ownership cost study for the Naval Sea Systems Command's Future Concepts and Surface Ship Design Group (SEA 05D) for the Littoral Combat Ship program. They are helping to evaluate the designs of both the Lockheed Martin and the General Dynamics designs, looking for changes in system design that may help to reduce costs. Some actions being studied are reducing the frequency of maintenance or reducing the number of components in a system. "Eventually, we'll be feeding reliability numbers and operating hour numbers to other NAVSEA components," says Dave Woodward, senior technical lead for the reliability modeling effort. "They will

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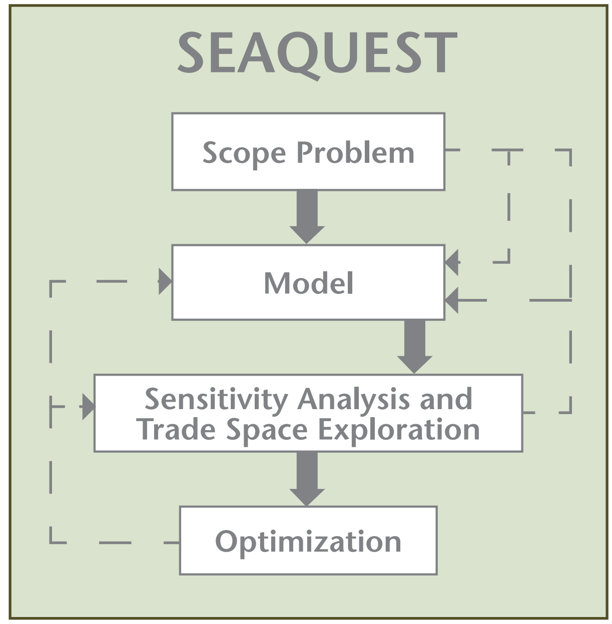
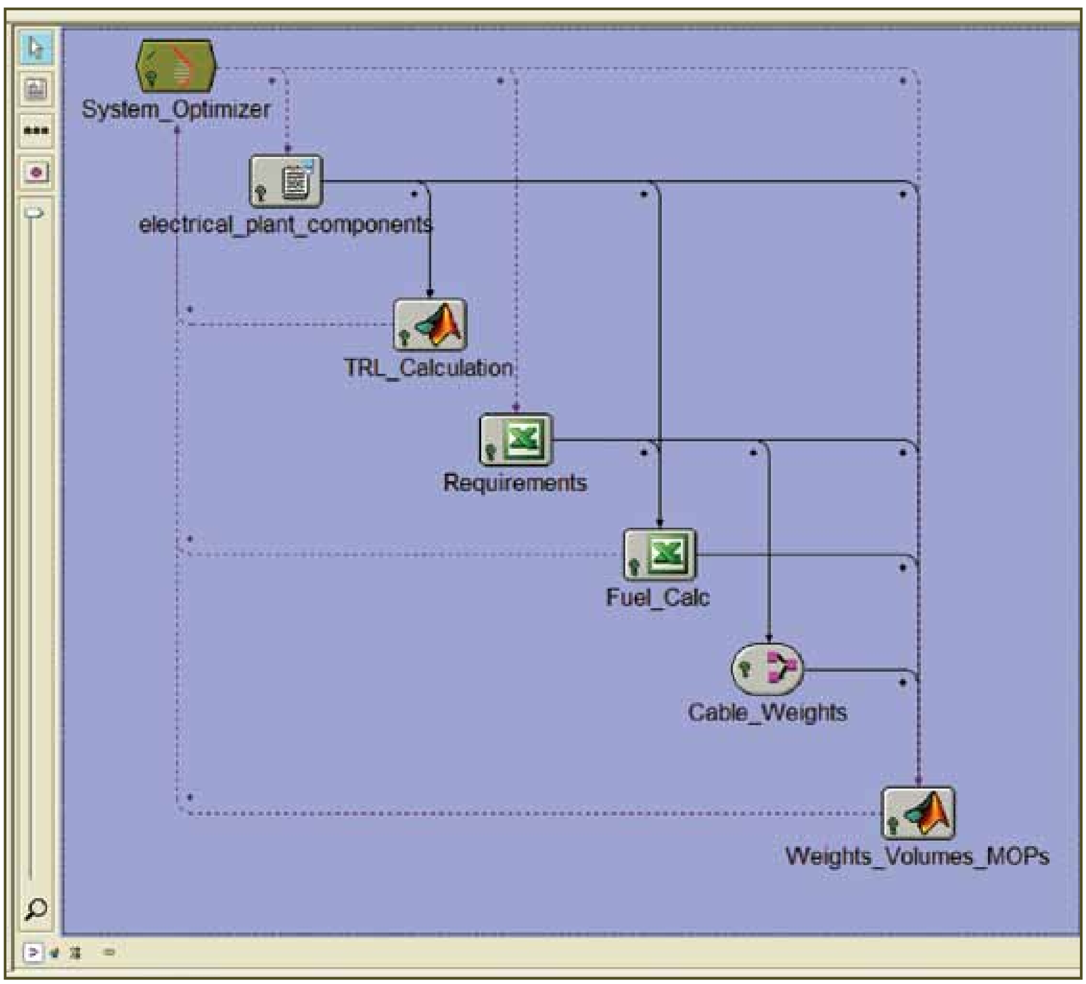
RELIABILITY MODELING (Continued from page 17)

generate logistics and manning impacts, and we won't really know how much money is saved until all those resultant costs are rolled together into a final sum."

This summation of outputs of individual modeling and simulation tools is viewed by Klingensmith and his team as unique method of synthesizing tool outputs. It's unique because it's a technique not being used anywhere else in the Navy design community at present. "They're basically doing point designs," says Rick Sheppard, the team lead in reliability modeling. "They generate a single design and carry it through to determine the viability of the design based on a small set of parameters. It's more cost-effective from a design standpoint to run a design through these different models together." Flexibility is greatly enhanced using the modeling and simulation approach and has been known to save money in the concept design process.

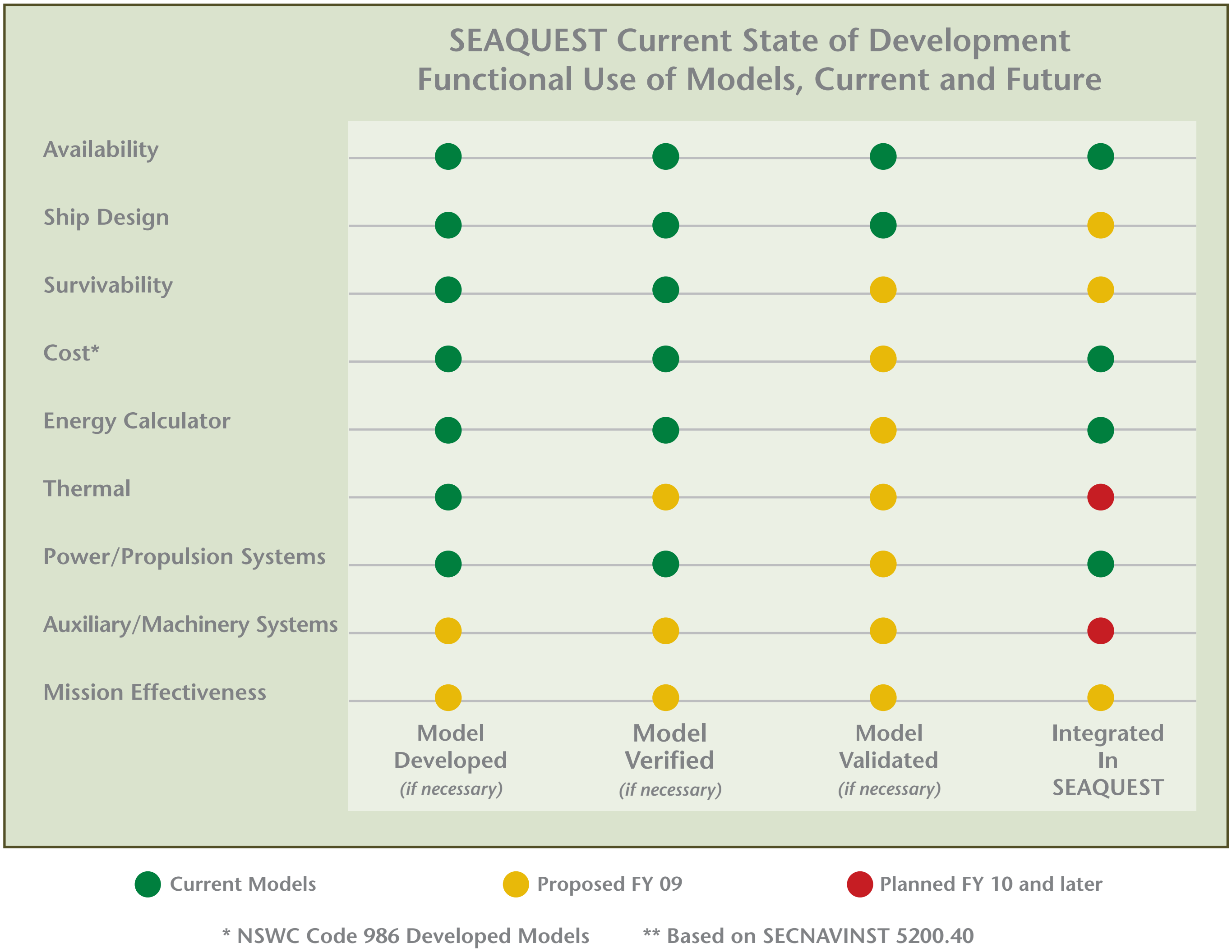


Top: Diagram of the Systems Engineering Application (SEA) process. The line diagram shows the steps taken by the software to quantify reliability in a ship system. *Diagram provided by William R. Sheppard, NSWC Carderock Division.*



Above: An example of the Full SEAQUEST model. This particular example depicts the cascading steps used in an alternative propulsion study. This method is more cost-effective from a design standpoint to process a design through different models together. *Image provided by William R. Sheppard, NSWC Carderock Division.*

Below: A chart showing the timeline of development of the SEAQUEST capabilities.
Diagram provided by William R. Sheppard, NSWC Carderock Division.



The team emphasizes they're not looking for any one design to satisfy all needs. More accurately, they're looking for a set of answers that feeds into a group of optimized designs which program managers can use in their decision-making process. This design optimization process has gotten so much attention recently that Klingensmith's colleagues participated in a very large alternative propulsion study presented to members of Congress in FY 06, spending almost $1 million to provide input to that report.

Through modeling and simulation, Carderock Division researchers are minimizing time and cost constraints on the Navy's ship design processes, paving the way for greater efficiency in designs, and in turn saving precious Navy budget dollars.

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Machinery Systems

Ship to Shore Connector

Aggressively Designing a New Air Cushion Vehicle to Meet the Operational Demands of an Improved LCAC Concept

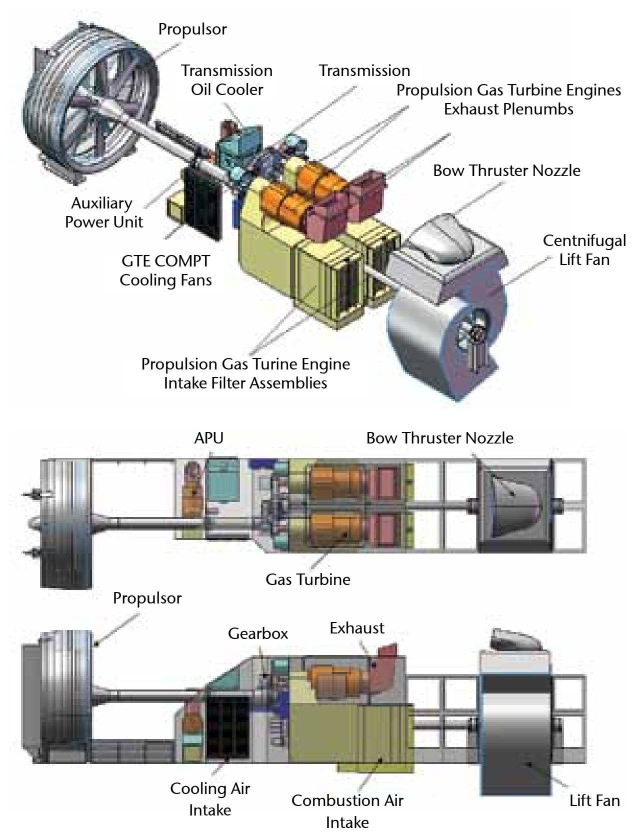
By William Palmer

In a government led design in which many of the core equities of the Naval Surface Warfare Center, Carderock Division, are involved, the next generation of the Landing Craft Air Cushion (LCAC) is being designed to meet new and improved operational requirements. This new Air Cushion Vehicle (ACV) design, titled the Ship to Shore Connector (SSC), engages just about every expertise Carderock Division designers and researchers can bring to bear on a design solution.

The aging LCAC fleet is currently undergoing a Service Life Extension Program (SLEP) that will add an additional 10 years to the original 20-year life cycle. However, as systems, components, and material start to age and eventually experience end-of-life issues on both LCAC and LCAC SLEP craft, there is a significant need to obtain the new, improved and cost-effective SSC to continue amphibious operations in the future. The SSC shares similarities to LCAC in its basic ACV design concept as well as the requirement to access the same well decks used to transport LCAC during today's missions and the ability to transport the same type of payloads (i.e., tanks, trucks etc.). "The notional SSC design may look very similar to an LCAC from an outsider's perspective due to similarities in size and dimensions," says Carderock program manager Tim Sipe, the program's customer advocate and liaison between Carderock and the SSC program office within Program Executive Office Ships (PEO SHIPS). "However, once you start drilling into the major systems and sub-systems, there are significant differences." The SSC is being designed to have greater lift and payload capacity (74 short tons) and a much longer range than the LCAC in the same operating environment.

The SSC design is made up of major functional elements that consist of hull, machinery, command/control/communication/computer/navigation systems (C4N), auxiliaries, performance and design integration. Of those six functional elements, Carderock is either leading or has a significant role in four of them: hull, C4N, machinery, and design integration. The Division's Ship Systems Engineering Station (SSES) in Philadelphia is contributing in great measure to the effort, being chiefly responsible for the design of the machinery package, which consists of everything needed to 'float' the vehicle, power, maneuver, and propel it. SSES is also leading the C4N design as well, and provides support for specific elements which consist of navigation, engineering control systems, computer environment, and systems integration. Other warfare centers, NSWC Panama City and NSWC Dahlgren, are also participating in the design team.

Carderock Division has also provided testing support to the program. Lift fan testing has been completed at SSES, and hydrodynamic model testing has been performed at West Bethesda's wave tank facility. NSWC Panama City teamed with Carderock to conduct full-scale loads testing on their



Above: Drawing showing the equipment arrangement for the SSC's power plant and propulsor. SSCs are similar to LCACs regarding air cushion vehicle technology.
Graphics provided by Tim Sipe, NSWC Carderock Division.

Above: LCACs like the one pictured above are currently in a life-extension program that will add 10 years to the vehicles' service life. There will be a significant need for the SSC once LCAC end-of-life component and material issues start to appear. *U.S. Navy photo.*

R&D LCAC craft, characterizing structural loading in high sea states likely to be encountered in real life. The design development of the SSC craft is leveraging actual data gathered from LCAC assets, with full-scale load testing and hydrodynamic testing performed using LCAC models. Since a full-scale SSC vehicle does not exist yet, the LCAC-derivative data is being used and can be modified to fit SSC parameters as the SSC design matures.

As Carderock Division supports the SSC design there is also a significant focus on improving reliability and maintainability while reducing total ownership costs. Jeff Merlino, the machinery systems integrator for the SSC project, says one of the unique aspects of this project was that the program office responsible for the platform's acquisition and life-cycle management are one in the same. "Typically in these situations," he says, "you have a program manager responsible for acquisition through delivery, and another program manager responsible for managing in-service assets. We've been given a unique opportunity in that [the two are] the same person. The benefit of that has been us being held more accountable [than most before us] with our early design decisions based on how they affect life-cycle cost effectiveness."

The design has come through an analysis of alternatives, as well as a set-based design period. The preliminary design is complete and is currently in the contract design phase. The Design Acquisition Board (DAB) granted Milestone A approval in the third quarter of FY 09, and since then the contract design phase has been in full swing. The first SSC craft is expected to be delivered in FY 16 and will be a test and training craft that will be used by the Navy for test, training, and further research and development studies. Follow-on craft will become fleet assets with delivery to the fleet expected in FY 17.

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ACCELERATED INSERTION OF MATERIALS

Replacing Iterative Testing with Software-Based Predictive Tools

By William Palmer

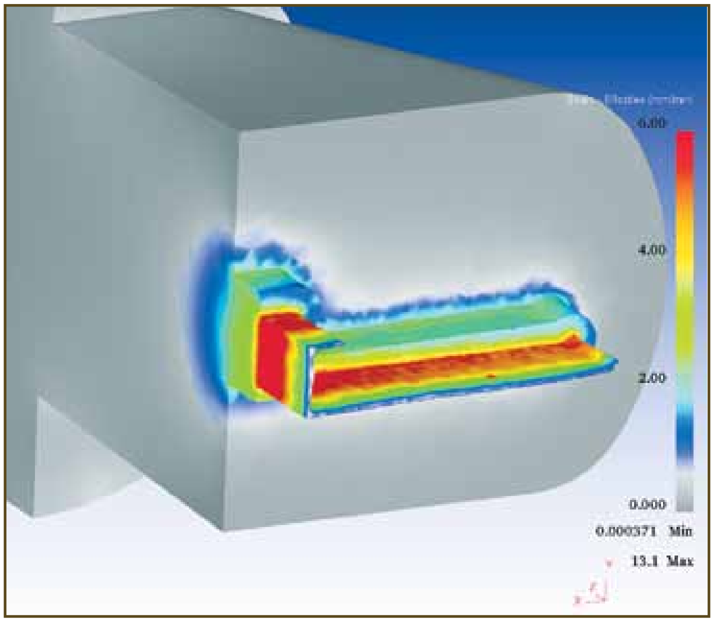
When dealing with materials in a shipboard environment, ship designers have to know material qualities such as strength, ductility, toughness, and fatigue and corrosion resistance before they can be used on a ship. Naval Surface Warfare Center, Carderock Division (NSWCCD) researchers would like to take advantage of new metal alloy combinations, but are up against a long design cycle in getting to know how the complex interplay between new materials and fabrication processes affects these properties. It can take years for a new alloy to go through the design and testing process to become qualified as a ship construction material and enter into production.

In an earlier Defense Advanced Research Projects Agency (DARPA) sponsored program, General Electric, maker of aircraft turbine engine components, used commercially-available software-based computational tools which could show metallurgists how an alloy's properties could change when its composition and processing were changed. Their cycle for jet engine turbine blade design and insertion was reduced from 12 years down to six. Because of this success, Dr. Julie Christodoulou of the Office of Naval Research (ONR) approached Carderock to develop a similar system for naval materials. The Navy's accelerated insertion of materials (AIM) program was thus born about four years ago, and Carderock materials engineers turned back to the aircraft industry as their starting point. The Carderock team, led by materials researcher Dr. David Forrest, is using GE's architecture as a template to simulate the microstructural evolution of Naval alloys during production, with the similar goal of reducing iterative testing of alloys, and cutting Naval alloy design and qualification cycles. The effort is guided and funded by ONR, with support from NSWCCD and Technology Stewardship funding.

Since Carderock initially had no team and no organized resources in place, Forrest had to build a program from the ground up. High-performance computing resources were available at the on-site SEATECH computing center, and total investments of about $200,000 were made in software modeling packages and software maintenance. Forrest also had help from Dr. Dan Backman, a retired GE program manager and renowned expert in the field, who had set up the AIM program for GE.

While a number of software modeling and analysis tools could simulate the extrusion process or calculate microstructural features, an essential feature of an AIM system is the integration and automation of these tools. `They must be able to "talk" to each other despite the lack of a common format for input and output, because the software routines were written to work independently, not in concert with each other. Fortunately, iSight, a software package capable of harmonizing the formats, had been used successfully in the DARPA-funded work and was available.

Once the means of simulating the processing was in place, researchers turned their attention to an extrusion process used by United Kingdom vendor Sapa Profiles, Ltd., to produce an AA6082 aluminum alloy-based sidewall panel with integral stiffeners for the second Littoral Combat Ship (LCS) design. Researchers wanted to use this process as a target with which to validate the accuracy of their alloy modeling programs, because the programs would have to model a deformation, which in reality occurs when an alloy ingot is pushed through a die (much like playdough through a form) to shape the LCS panel. Also, engineers wanted to accurately model the heat treatment process. Magnesium silicide nanoparticles come out during heat treatment to strengthen the alloy, and engineers found it necessary to model the number and size distribution of the particles in order to predict the strength of the material.



Left: A visual representation of the temperature and strain calculations for the extrusion of the LCS sidewall panel. Carderock Division researchers used a system similar to the one developed by General Electric. The GE system provided a methodology and computational framework for accelerating the insertion of materials into an application, and resulted in an estimated 45 to 70 percent reduction in insertion time for a nickel-based superalloy into a turbine disk application, largely due to reduced testing requirements. New materials for Naval applications also require substantial qualification testing. Through the use of the AIM Modeling and Simulation toolsets, researchers have an opportunity to realize economies in the Naval materials qualification process. *Image provided by Dr. David R. Forrest, NSWC Carderock Division.*

Left: A section of the extruded AA6082 aluminum alloy-based LCS sidewall panel with integral stiffeners. The AIM promises to make an impact on the time required to qualify a new material for shipboard use, but the amount of time reduction will vary depending on the material chosen for a particular application, as well as how the material will be used." *Photo by William Palmer, NSWC Carderock Division.*

To start the modeling process on a simplistic footing, two properties, hardness and strength, were targeted. "For our demonstration project," says Forrest, "we wanted the modeling process to be difficult enough so we could show we actually had a system that was pretty functional, but not so difficult that we couldn't do it at all. The reason we chose this particular alloy is that it is already in use in the fleet, and we needed a material which already had valid data we could work with." To help accurately model the magnesium silicide particles, called a precipitate, in the AA6082 alloy, Forrest turned to PrecipiCalc, a software package which calculates precipitate distribution within a material. This was an important part of the modeling efforts, because the precipitate particles are dominant in determining the strength of the alloy, and Forrest wanted to be sure he could accurately model the particles.

Although Forrest knows he can reduce the amount of time needed to qualify a new material for shipboard use, exactly how much time remains to be seen. "You almost have to do a case study," he says, "and, depending on the material you pick and what its application is, it's still going to vary as to how long it will take to get a new material on board a ship. It will still be on the order of years to qualify the new material, but not decades. It may be two years, or five years, and much will depend on how critical the component is."

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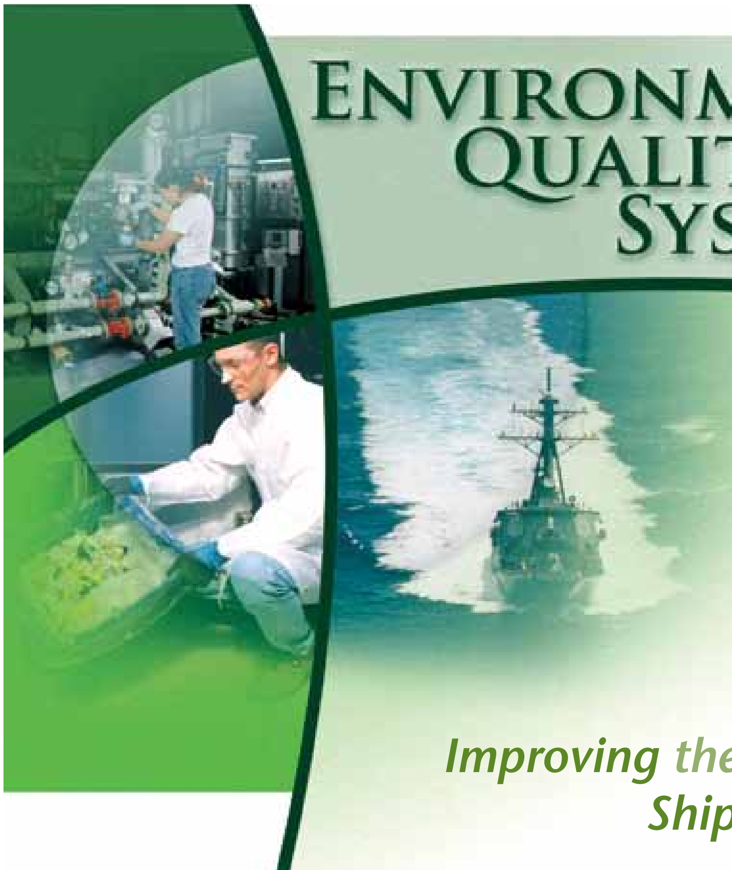
ENVIRONMENTAL QUALITY SYSTEMS



PLASTIC WASTE PROCESSOR

Improving the Ability of New Construction Ships to Process Plastic

By Martin Cohen

The Navy's Environmental and Natural Resources Program Manual requires the fleet to meet a zero plastic waste discharge requirement (unless ship safety or the health and safety of the crew are compromised). A U.S. Navy aircraft carrier generates nearly 1,000 cubic feet (30 cubic yards) of plastic waste per day. By comparison, smaller ships can generate nearly 50 cubic feet of plastic waste per day. While plastic waste can be removed from ships during underway replenishments every three to four weeks, the average aircraft carrier can generate up to 30,000 cubic feet (1,000 cubic yards) of plastic waste during that time, and the average surface combatant up to 1,500 cubic feet (more than 50 cubic yards).

Considering that ships cannot discharge plastic waste overboard, it is easy to see the potential havoc that this can wreak on operations during a deployment of a U.S. Navy ship. Plastic waste processors (PWPs), also referred to as compressed melt units (CMUs), were originally designed and outfitted in the fleet from late 1995 through 1998, and are used by the fleet to process shipboard generated plastic waste into dense disks suitable for long-term storage onboard prior to shore disposal. PWPs reduce the volume of plastic waste by a 30:1 ratio. These processors allow ships to retain their plastic waste onboard when at sea and comply with zero-plastic waste discharge requirements, while enabling them to operate unrestricted throughout the world.

Fleet operations have shown that the original design PWPs required excessive man-hours to operate and had high corrective and preventative maintenance costs. Additionally, PWP cleanliness issues related to the processing of food contaminated plastics have impacted the fleet. In FY 00, the Naval Sea Systems Command (NAVSEA) directed Naval Surface Warfare Center, Carderock Division's (NSWCCD's) Environmental Quality Department to improve the PWP design. The initial goals were to reduce operational and maintenance man-hours associated with the equipment by 40 percent without modifying the shipboard interfaces, and enhance the cleanliness of the equipment.

Assessments were made on the failure rates of all components, corrosion, and system complexity. High failure rate components were removed or replaced. Materials were changed to reduce corrosion issues, and the system was greatly simplified to enhance reliability, and ease maintenance and cleaning. Replacement components and subsystems were designed, fabricated, and then tested for reliability and ruggedness in the laboratory and in the field. The modified plastics waste processor (MOD I PWP) has 34 percent fewer components and a processing rate 200 to 300 percent greater than the legacy PWP. Also, the electrical and drive systems were revamped to enhance simplicity and dependability, and support increased processing rates.

The lower frame of the unit was redesigned to promote ease of cleaning, which is important due to the processing of food contaminated plastic waste. The modified unit incorporates self-cleaning nozzles that are connected to the ship's hot potable water service, greatly reducing

Above left to right: MOD I Plastic Waste Processor installations aboard the *USS Millius* (DDG 69) (the current design compressed melt unit is to the right of the PWP); the *USS Laboon* (DDG 58); and the *USS Antietam* (CG 54). These PWPs reduce the volume of plastic waste to the extent that the waste is retained onboard for the duration of their at-sea time, enabling the ships to comply with zero plastic waste discharge requirements.
Photos provided by Martin Cohen, NSWC Carderock Division.

the amount of cleaning time and effort by ship's force. Ultimately, Machinery Alterations (MACHALTs) for surface ships and ship alterations (SHIPALTs) for aircraft carriers were chosen as the means by which this equipment would be backfitted to fleet assets.

The MACHALTs and SHIPALTs did not apply to new-construction ships such as *USS George H.W. Bush* (CVN 77), *USS America* (LHA 6), *USS Makin Island* (LHD 8), and the *USS Arleigh Burke* (DDG 51) and *USS San Antonio* (LPD 17) ship classes. NAVSEA and NSWCCD lobbied to have the ship program managers change the ship specifications to purchase the new MOD I PWP equipment. Changing to MOD I PWPs also provided a direct cost savings for some ship programs, since the increased processing rate of the MOD I equipment permitted a reduction in the number of PWPs required. *Bush* went from a baseline of 10 legacy PWPs to six MOD I units. Likewise, *America* and *Makin Island* went from six legacy PWPs to four MOD I units. At a cost of approximately $50,000 for each PWP, cost savings on these two amphibious ships was over $100,000 per ship. *San Antonio* Class ships went from three legacy units to two MOD I units for a cost savings of over $50,000 per ship.

DDG-51 Class ships initiated an ECP to purchase the PWP MOD I equipment starting with DDG-107. So far, this equipment has been procured for installation on ships up to DDG-112. New DDG-51 Class shipbuilding will have this equipment written into the original contract.

Finally, current plans call for the acquisition and installation of the PWP MOD I on CVN-78 and DDG-1000. It is NAVSEA's intention to require this equipment for all future ship acquisition programs that require plastics processing to effectively manage the waste stream and comply with current directives.

Above: The *USS George H.W. Bush* (CVN 77). Machinery and ship alterations did not apply to this aircraft carrier and other new-construction vessels, but ship specifications were changed to purchase MOD I PWPs. Ten legacy PWPs were replaced by six MOD I units. To date, NSWCCD has completed machinery and ship alteration installations aboard 81 ships.
U.S. Navy photo.

Installation of MOD I PWPs to the active fleet by MACHALT and SHIPALT was started in FY 05. To date, NSWCCD has completed MACHALT/SHIPALT installations on 81 ships. MOD I PWP MACHALT/SHIPALT installations are scheduled to complete in FY 16 with installations planned for a total of 130 ships, with an added 20 ships receiving MOD I PWPs during new construction or through other means.

The installation of MOD I PWPs on 130 ships provides significant benefit to the fleet in operation and maintenance manpower savings, and enhances the ability of Navy ships to meet Navy environmental requirements while performing their assigned missions.

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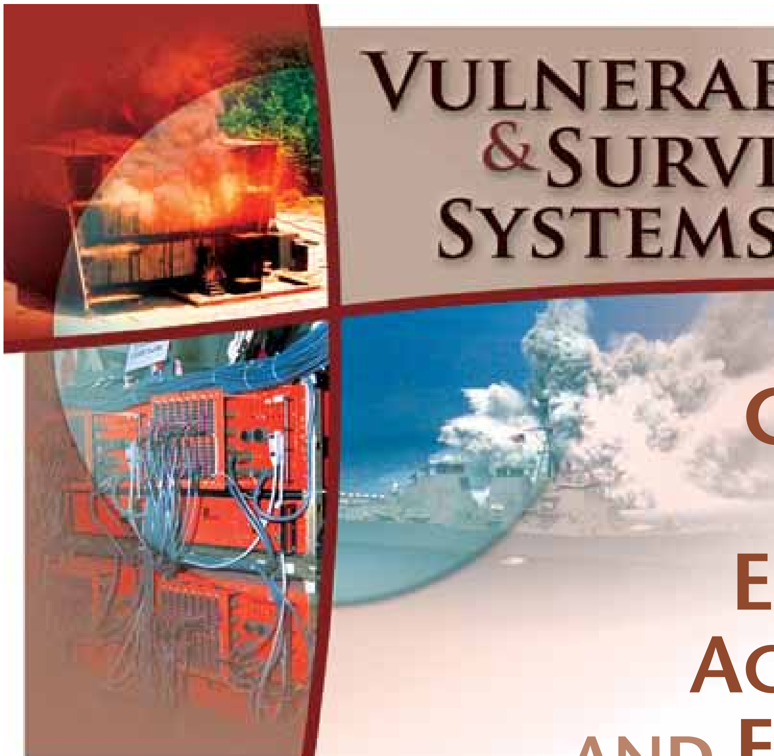

Vulnerability & Survivability Systems

Computational Research and Engineering for Acquisition Tools and Environments

Predictive Software that Should Save Money on UNDEX Trial Costs

By William Palmer

In 2006, the Secretary of the Navy, Dr. Donald C. Winter, announced an initiative to enhance the Department of Defense's ability to perform modeling and simulation, expecting the initiative to have a beneficial impact on such activities as ship design and acquisition. Shortly after the initiative was launched, the High Performance Computing Modernization Office initiated the Computational Research and Engineering for Acquisition Tools and Environments (CREATE).

CREATE consists of three projects: Ships, Antennas and Aviation. Within the Ships project there are four products, one of which uses modeling and simulation software–written in a combination of C++ and Fortran 90–to predict the effects of underwater explosions, or UNDEXs, shock effects and damage resulting from such events. A team of experts from the Naval Surface Warfare Center (NSWC), Carderock Division, consisting of Dr. E. Thomas Moyer, one of 28 Navy-wide Senior Research Scientist, mechanical engineer Ray DeFrese, and Dr. Mary Vechery, heads up development efforts, both in-house and in concert with personnel from NSWC Indian Head Division and Sandia National Laboratories.

The team's goal is to develop the next-generation modeling and simulation software for specific applications, in this case shock and UNDEX events. To accommodate the computation-intensive tasks CREATE would have to perform, both high-performance computing resources and the expertise of personnel knowledgeable about the dynamics of shock impact energy on a structure had to be applied. "The actual software development started in FY 08," said Moyer, "and we're leveraging heavily off of existing code, such the Sandia Lab Salinas code, Indian Head's Gemini code, and general LaGrangian routines. We are adding to these programs, not rewriting them."

Another challenge for the team is to add the unique modeling and simulation needs of the Navy to the assembled collection of computer applications. Products from the Department of Energy's (DOE's) Advanced Scientific Computer program, which CREATE uses, address analysis of solid structures, for example, but needed enhancement (e.g., shell elements) because of the specific requirements of the naval shock environment. Another needed feature of DOE applications is what Moyer terms "massively parallel" computing systems, meaning that several computing tasks are executed simultaneously, or in parallel, greatly increasing the efficiency of the systems and the accuracy of their output.

High-level Navy officials have put their support behind CREATE. The CREATE Ships board of directors, chaired by Rear Admiral Thomas J. Eccles, has recently signed the Initial Capabilities Document, which describes capabilities the software is expected to achieve. A memorandum of agreement among the various program offices and their sponsors is being developed to formalize the relationship between the CREATE Ships project and the

*Above: The USS Theodore Roosevelt (*CVN 71) undergoes open-ocean shock trials. Such events are costly to the Navy, and CREATE uses modeling and simulation software to predict the effects of underwater explosions, shock effects and damage resulting from such events.
U.S. Navy photo.

NAVSEA Ship Design, Integration and Engineering directorate modeling and simulation mission statement issued by Vice Admiral Paul E. Sullivan in 2008.

Modeling and simulation has for many years been a key element of the design of ships and submarines to withstand UNDEX shock. One of the many challenges in ship design is developing design requirements for new systems without using input from a real UNDEX event. The CREATE software facilitates simulation of both the event and the ship structure's reaction to that event. The process is the outgrowth of efforts used in support of the *USS San Antonio* (LPD 17) Class, the *USS Virginia* (SSN 774) Class and the *USS Zumwalt* (DDG 1000). "We used modeling and simulation during the design," says Moyer, "because we didn't have a ship to test. Also, when we design new shipboard systems, the first thing the system designer asks about are the UNDEX loads the system may encounter. We use modeling and simulation to help estimate those design loads. The more accurate we can be earlier in the design, the less risk there is. We have a vested interest in making the system designers and the ships successful, and CREATE is the tool which will facilitate that."

In fact, CREATE will be onboard ships when they undergo UNDEX trials, not to collect test data, but to validate its own structural response predictions with real-time data. This is a critical component of bringing CREATE to a high level of efficiency and accuracy, because the real data exposes areas where the modeling and simulation can be improved. "The data tells us what aspects of the code are slowing us down and also where we are doing too good of a job," says Moyer. He adds that an important design consideration does not just know what to model and how to model it, but also what not to model. The modeling and simulation process can generate too much data in one area, over-stating the accuracy of that portion of the simulation, and reducing its efficiency. For example, the chemical thermodynamics of the explosion, and resultant molecular heating on the ship due to explosion-induced stresses, are examples of processes that are difficult or impossible to model, and are not of significant relevance to the problem at hand. The software designers and researchers have to define what parts of the simulation process to express. "It may look like science," says Moyer, "but it's more of an engineering process. You've got to know what matters and what doesn't. Mother Nature, expressing herself through the UNDEX tests, tells you that."

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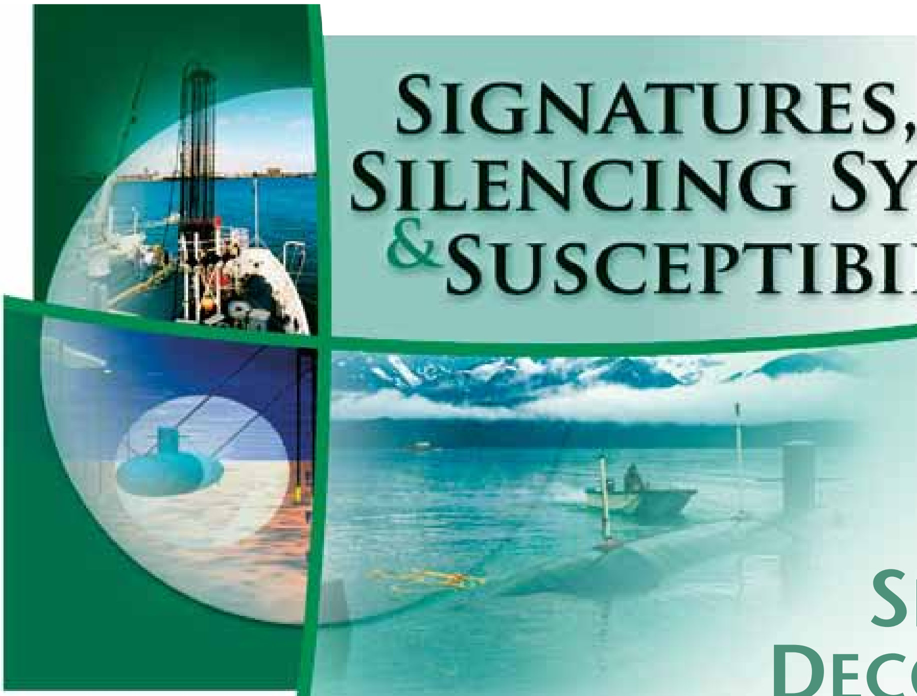


Signatures, Silencing Systems, & Susceptibility

Signature Decomposition Analysis

Saving At-Sea Acoustic Trial Costs Through Computer-Based Analysis

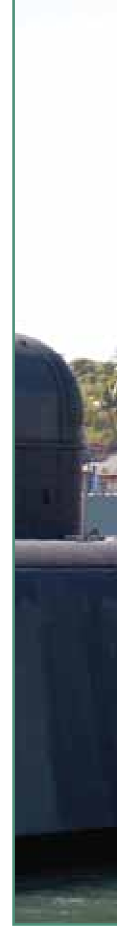
By William Palmer

Recently, researchers at the Naval Surface Warfare Center, Carderock Division, were tasked to measure the acoustic signature of *USS Florida* (SSGN 728), a former *Ohio*-Class submarine which had been converted to the SSGN submarine class–a class capable of carrying payloads to support special warfare operations. Initially, the plan was to measure the boat's signature with an outer appendage, called a Dry Deck Shelter (DDS), attached, and also without the DDS, for comparison purposes. Due to changing schedules and demands on the boat's operating schedule, only one trial, with the DDS attached, could be executed. But the researchers came up with a way to measure the submarine's "bare-hull" configuration without putting the boat through a second trial.

The method, called signature decomposition analysis, was created from a process called beamforming, which enables trial personnel to pinpoint a noise source. The Florida's trial was done in FY 07 and lasted for five days, during which the sub's signature was measured. But, instead of putting the boat through a second trial, members of Carderock Division's Performance Assessment, Modeling and Simulation, and Special Projects branch adapted the beamforming procedures to predict the Florida's bare-hull signature. Since the rest of the *Ohio*-Class fleet operates bare-hulled, there was plenty of prior trial data to corroborate the prediction. And the results were accurate, so accurate that the researchers presented their findings to program sponsors at NAVSEA's SSGN program office, which concurred with the prediction, permitting the modeled signature to stand as a valid representation of the Florida's signature.

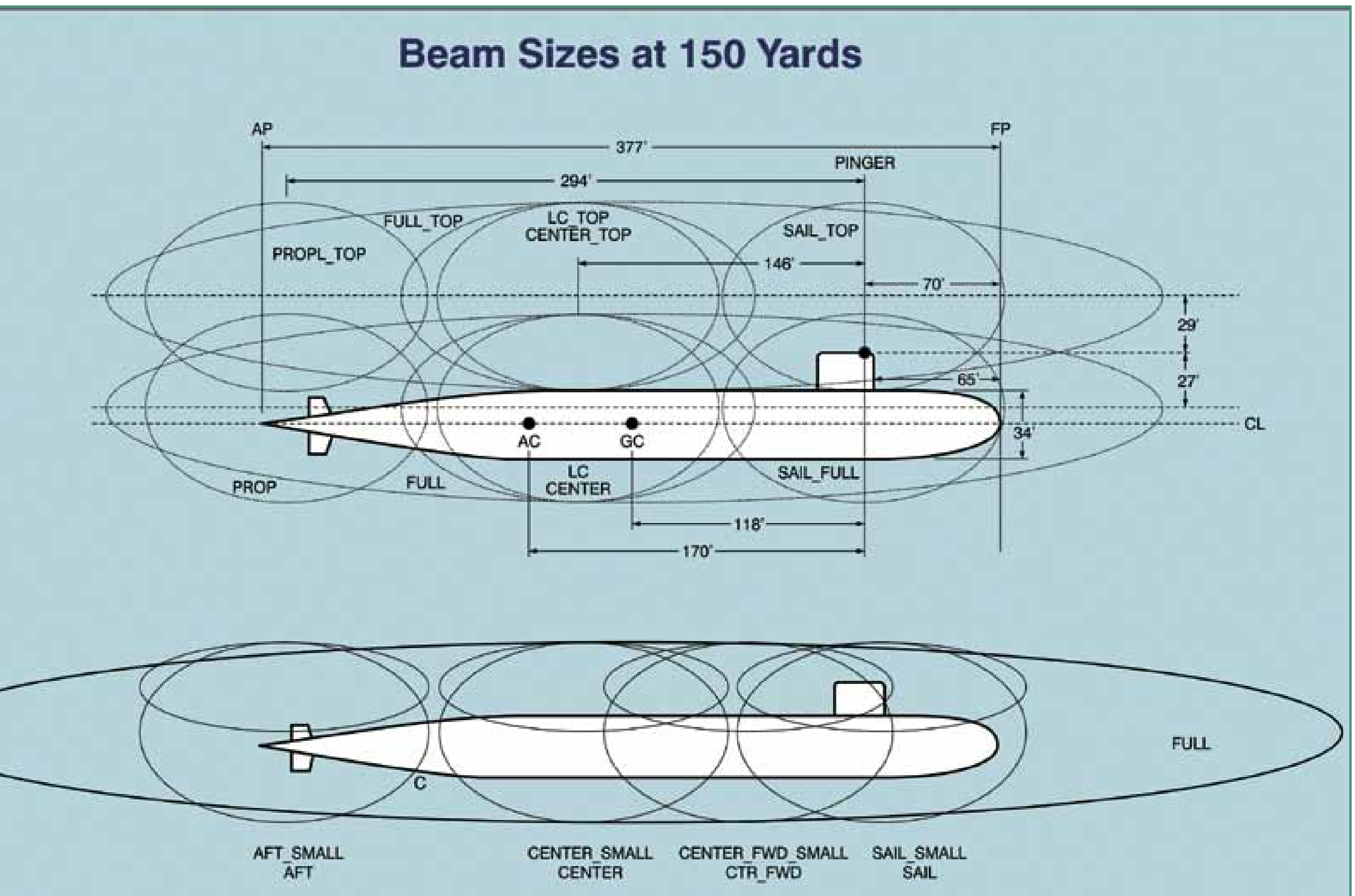
As a result, about $350K was saved in trial expenses. These savings were realized across a broad range of concerns, such as eliminating logistical, hardware and operational risks associated with conducting such a trial; 5 to 6 days of ship time spent conducting the trial; and the cost associated with installing and removing a DDS. Because of their success in closely modeling the bare-hull signature, and because the model closely agreed with prior *Ohio*-Class data, the Carderock personnel have won the support of the *Ohio* Replacement Program. "This was one of the first of these types of analyses," says Steve Jackson, a mechanical engineer, acoustic trials program manager, and liaison between the NAVSEA program office and Carderock Division. "It was a first on the SSGN/SSBN class. It's

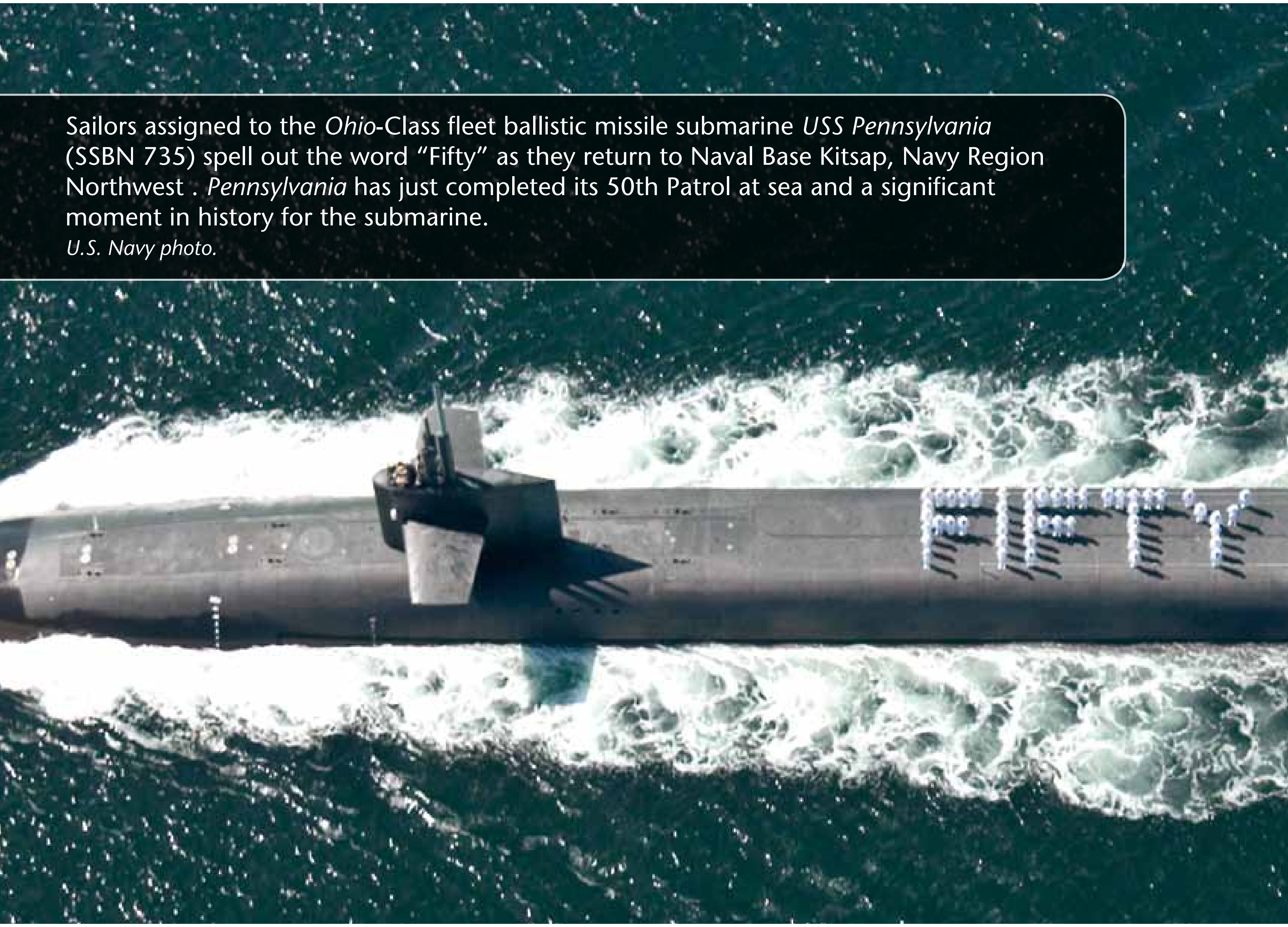
SIGNATURE DECOMPOSITION (Continued on page 30)



Left: The *USS Ohio (*SSGN 726), a former ballistic missile submarine converted for use as a multi-purpose platform. On the *Ohio's* afterdeck is a dry deck shelter.
U.S. Navy photo.

Below: Details of spot beams.
Image courtesy of Mike Marsh and rerendered by Gary Garvin, both NSWC Carderock Division.





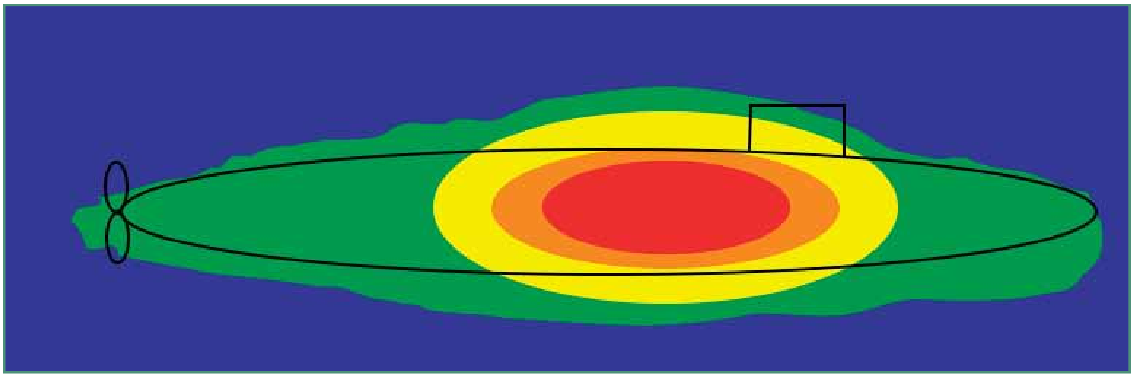
Sailors assigned to the *Ohio*-Class fleet ballistic missile submarine *USS Pennsylvania* (SSBN 735) spell out the word "Fifty" as they return to Naval Base Kitsap, Navy Region Northwest . *Pennsylvania* has just completed its 50th Patrol at sea and a significant moment in history for the submarine.
U.S. Navy photo.

SIGNATURE DECOMPOSITION *(Continued from page 28)*

been very useful in advancing, proving, and refining the technique. It will also be beneficial for future design work and research and development efforts."

Nelson Keech, a mechanical engineer, chief engineer for Carderock Division's signature analysis efforts, and a longtime veteran of acoustic investigations, first introduced the decomposition technique during the introduction of the *USS Seawolf (*SSN 21) into the fleet. "With the quieter signatures," he says, "we had to go into a more in-depth analysis to fully quantify those signatures. The critical thing was development of high-gain [hydrophone] arrays to generate narrow-width "spotbeams," which basically allowed us to dissect the signature. That followed on from the *Seawolf* to the *Virginia* Class, and now we're using it with the SSGN." The spotbeams were initially developed as a quality control tool, but trial personnel realized the tool could be used to focus on minor components of a signature. The Performance Assessment community eventually expanded the use of the tool to bring about the decomposition analysis.

Mike Marsh, Acting *Virginia* Class/SSGN Program Manager, says it has been about a 10-year process to calibrate and use the beams, and develop the methods to the point where trial personnel could use the spotbeams to measure signature levels. "It used to be one big beam," he explains, "to make one measurement of the entire submarine. We broke that down into components and eventually were able to calibrate those components by various means. Every year or so, we would do a trial, take data, learn from it, improve our processes, and do another trial. Eventually, we arrived at the current methods to do this kind of analysis."



Left: Colors delineate a typical area of acoustic intensity detected with accuracy by spotbeams.
Image courtesy of Mike Marsh, NSWC Carderock Division..

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TECHNOLOGY & INNOVATION

HIGH TEMPERATURE DEGAUSSING

Saving the Fleet Fuel Costs, Weight, and Voltage

By Theresa Vaites

On April 1, 2009, the *USS Higgins* (DDG 76) passed over the U.S. Navy Magnetic Silencing Range outside San Diego, Calif., producing a "full coil" effect. This successful test run of a new High Temperature Superconducting (HTS) degaussing system, was a major milestone in a multi-year project guided by representatives from Naval Surface Warfare Center Carderock Division's (NSWCCD's) Machinery Research and Silencing, and Underwater Electromagnetic Signature and Technology divisions, and sponsored by the Office of Naval Research (ONR).

In 2004, ONR tasked these groups with completing a feasibility study of the use of superconducting technology for building an advanced degaussing system for the U.S. Navy. It was predicted that the use of a superconducting cable-based system would provide a significant cost saving to the fleet over existing degaussing systems, which require hundreds of meters of copper wire. The results of the study did indeed show that the use of HTS technology would provide a potential reduction in installed costs of about 40 percent when compared to a traditional copper cable-based system.

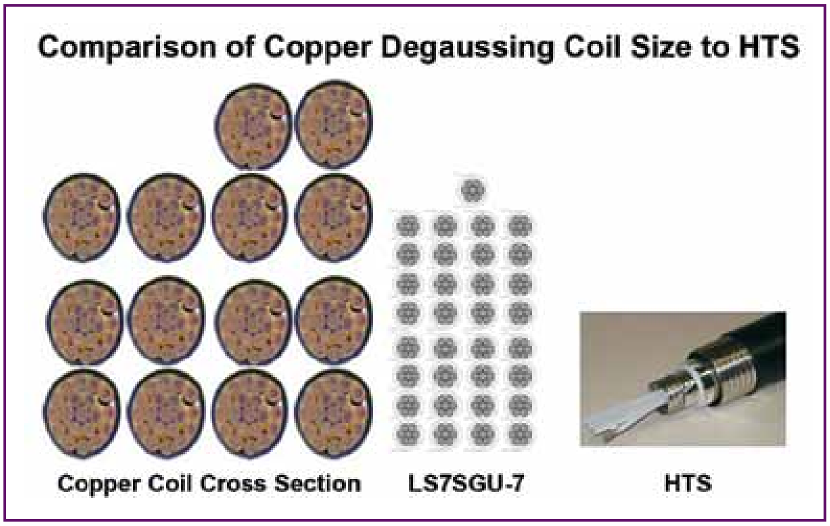
"The HTS coil is made of ceramic material that replaces the copper coils," stated Brian Fitzpatrick, lead project engineer. "The superconductivity of this new degaussing system means less energy is required, yet it enables greater degaussing performance. Additionally, there is significant weight savings–up to 80 percent in some cases."

The HTS degaussing systems projected for ship classes with advanced degaussing systems show an estimated 50 to 80 percent reduction in total system weight, which offers significant potential for fuel savings, or options to add different payloads. In addition, the HTS cables have no resistance providing a reduction in operation from 500.0 volts to 0.5 volts.

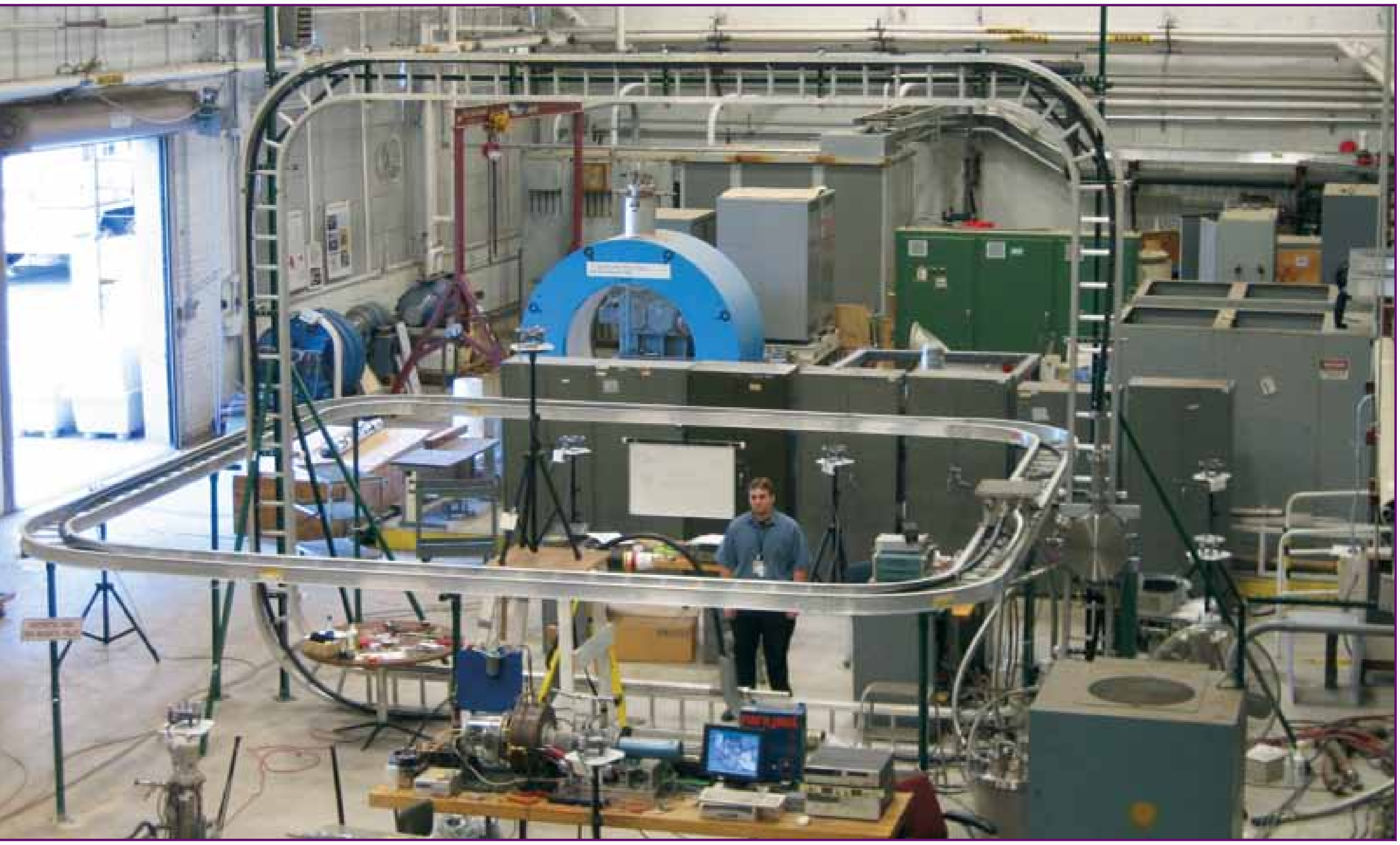
The advanced degaussing system, developed by Carderock Division engineers John Holmes, Milton Lackey, Shirley Steffey, Richard Mack, and Robert Wingo, neutralizes the magnetic signature of the ship, created as the steel hull of the ship passes through the water, in the same manner as a traditional system. Electrified cables are run on multiple axes of a ship hull to counteract the magnetic field disruptions that allow a ship to be "seen" by magnetically activated mines. Since 1950, mine strikes have caused 77 percent of the U.S. Navy ship causalities.

Fitzpatrick, along with engineers Jacob Kephart, Peter Ferrara, and Michael Pyryt constructed an initial operational one-loop demonstration system using commercially available components, in support of the U.S. Naval initiative to make use of Commercial Off-the-Shelf (COTS) equipment to provide a cost effective quick transition of technology to the fleet. A second loop was later added to the model with the cooling provided by a single cryocooler to eliminate the significant system cost of using a second cooler. A call to industry was also made to solicit proposals for HTS cables that would be able to withstand the shocks and vibrations of the naval environment, and for designs of quick disconnecting cables and junction boxes that would enable easier maintenance and repair of installed advanced degaussing systems through the ONR and NAVSEA PEO Ships Small Business Innovative Research (SBIR) programs.

HIGH TEMPERATURE DEGAUSSING (Continued on page 34)



Above: The *USS Higgins* (DDG 76), with a high-temperature superconducting degaussing onboard, successfully completed a test run at the Navy's Magnetic Silencing Range by San Diego. HTS systems can potentially save the Navy in total system weight, fuel savings, and increased capability through added varying payloads.
U.S. Navy photo.



Above: Photo of the HTS test stand at NSWCCD's Ship Systems Engineering Station at Philadelphia, Pa.

Left: A cutaway view of the high-temperature superconducting cables.
Photos courtesy of Theresa Vaites, NSWC Carderock Division.

HIGH TEMPERATURE DEGAUSSING (Continued from page 32)

Multiple patent disclosures have been filed by the researchers in relation to work done on this research initiative. In recognition of their work on the project, Fitzpatrick, Kephart, Denis Colahan, and ONR Program Officer George Stimak were named as Top Navy Scientists and Engineers of the Year award winners.

The prototype system installed on the *Higgins* makes use of the cumulative efforts of U.S. Navy civilian engineers, U.S. Navy sponsors, and our industry partners. It is a definitive example of the effectiveness of joint public-private technology development programs that enable quick transition of emerging technologies to the fleet to support continued U.S. Naval supremacy and affordability.

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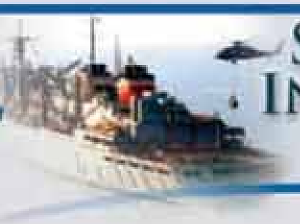
Ship Integration & Design



This core equity applies specialized expertise for surface and undersea vehicle design including early concept development, assessment and selection of emerging technologies, integration of selected technologies into optimized total vehicle designs, and evaluation of those technologies and designs for cost, producibility, supportability, and military effectiveness.

Machinery Systems

This core equity provides full-spectrum technical capabilities (facilities and expertise) for research, development, design, shipboard and land-based test and evaluation, acquisition support, in-service engineering, fleet engineering, integrated logistic support and concepts, and overall life-cycle engineering.

Hull Forms & Propulsors

This core equity provides the Navy with full-spectrum hydrodynamic capabilities (facilities and expertise) for research, development, design, analysis, testing, evaluation, acquisition support, and in-service engineering in the area of hull forms and propulsors for the U.S. Navy.

Vulnerability & Survivability Systems

This core equity provides full-spectrum capabilities (facilities and expertise) for research, development, design, testing, acquisition support, and in-service engineering to reduce vulnerability and improve survivability of naval platforms and personnel.

Environmental Quality Systems

This core equity provides facilities and expertise for research, development, design, human systems integration, acquisition support, in-service engineering, fleet support, integrated logistic concepts, and life-cycle management resulting in mission compatible, efficient and cost-effective environmental materials, processes, and systems for fleet and shore activities.

Signatures, Silencing Systems, & Susceptibility

This core equity specializes in research, development, design, testing, acquisition support, fleet guidance and training, and in-service engineering for signatures on ships and ship systems for all current and future Navy ships and seaborne vehicles and their component systems and assigned personnel.

Structures & Materials

This core equity provides the Navy with specialized facilities and expertise for the full spectrum of research, development, design, testing, acquisition support, and in-service engineering in the area of materials and structures.

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